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SEMICONDUCTOR PRESSURE SENSOR UNIT AND METHOD FOR ITS MANUFACTURE

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SEMICONDUCTOR PRESSURE SENSOR UNIT AND METHOD FOR ITS MANUFACTURE

[Halbleiterdrucksensorgerät und Verfahren zu dessen Herstellung]

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Description*

The present invention pertains to a semiconductor pressure sensor unit according to the preamble of Claim 1 and to a method for its production according to the preamble of Claim 9. It pertains in particular to semiconductor pressure sensor devices that are composed of semiconductor pressure sensor chips with a pressure sensor to determine a pressure, an amplifier circuit to boost the signal from the pressure sensor, and an electrode integrated on a semiconductor substrate and a circuit frame in which the semiconductor pressure sensor chip is installed. It also pertains to a method for manufacturing this device.

The method of direct connection of the semiconductor pressure sensor chip to the circuit frame is generally known in conventional semiconductor pressure sensor devices.

As is shown in Figures 12 to 14, a semiconductor pressure sensor chip has a pressure sensor 51 with an embedded measuring resistor to determine the pressure, an integrated circuit

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52 with a reinforcing circuit and such to boost the signal from the pressure sensor 51, electrodes 53 for the external connection and a diaphragm device 54 to form a diaphragm of the pressure sensor 51.

As is shown in Figures 15 and 16, a pressure frame 200 has an attachment section 20 that represents the chip attachment region therein, where the semiconductor pressure sensor chip is installed, a pressure absorption surface 3 formed in the attachment section 20, interior lines 5, an immersion element 6 to prevent the resin from overflowing, and outer lines 7.

As is shown in Figures 17 and 18, a semiconductor pressure sensor chip 50 is directly connected to the attachment section 20 of the circuit frame 200. The electrode 53 of the semiconductor pressure sensor chip and the inner lines 5 are connected by fine metal wires 6. As is shown in Figure 19, the attachment section 20 and the semiconductor pressure sensor chip 50 are attached to each other with an adhesive 30.

It was mentioned above that the semiconductor pressure sensor chip 50 is directly connected to the circuit frame 200 by the adhesive 30 in a semiconductor pressure sensor device. The coefficients of expansion of the circuit frame 200 and of the semiconductor pressure sensor chip 50 are different from that of the adhesive 30 of a conventional semiconductor pressure sensor device. This causes the generation of a thermal stress, which leads to difficulties inasmuch as tensile and flexural moments are exerted on the pressure sensor 51 of the semiconductor pressure sensor chip 50.

As is shown in Figure 20, the tensile and flexural moment F51 and M51 are generated by thermal disturbances in the pressure sensor 51 of the semiconductor pressure sensor chip 50. The tensile moment and flexural moment F30 and M30 are produced in the adhesive 30. Tensile and flexural moments F20 and M20 are produced in the attachment section 20. This yields the equilibrium state expressed by the following equations (1) and (2) in the case of a thermal disruption:

$$F_{51} + F_{20} + F_{30} = 0 \quad (1)$$

$$M_{51} + M_{20} + M_{30} = 0 \quad (2)$$

Therefore, the tensile and flexural moment F51 and M51 that act on the pressure sensor 51 of the semiconductor pressure sensor chip 50, are expressed in the following equations (3) and (4):

$F_{51} = -(F_{30} + F_{30})$ (3)

$M_{51} = -(M_{20} + M_{30})$ (4)

This results in the disadvantage that the distribution of thermal stress caused by the difference in the coefficients of expansion is not uniform, since the symmetry of the integrated circuit 52 and of the electrode 53 with the other sections is not suitable when the pressure sensor 51 is taken as the center as in Figure 19. This results in the difficulty that measurements of high accuracy cannot be obtained.

Therefore a method for attachment of the semiconductor pressure sensor chip to a circuit frame with a silicon base, that is formed from a silicon monocrystal, is needed to absorb and to minimize the thermal stress exerted on the pressure sensor 51. This method was selected based on the fact that the material and thus the coefficient of expansion of the silicon base is equal to that of the semiconductor pressure sensor chip, so that essentially the generation of thermal stress or strain will be suppressed.

Now in the method of attachment of the semiconductor pressure sensor chip 50 to the circuit frame 50 with the silicon base formed in between using a silicon monocrystal, first the semiconductor pressure sensor chip is joined with the silicon base. Then this silicon base is joined with the circuit frame 200, whereupon the electrode 53 of the semiconductor pressure sensor chip 50 is wired to the inner line 5 of the circuit frame 200 with a fine metal wire 15. This method for attachment of the semiconductor pressure sensor chip 50 to the circuit frame 200, however, requires the introduction of a silicon base to absorb and to minimize the thermal stress. Therefore, the bonding has to be carried out twice, so that the manufacturing method becomes more complicated and the costs are increased.

It is necessary to form a pressure measuring chamber (cavity) to measure the air pressure in the circuit frame with semiconductor pressure sensor chip 50 attached as in Figures 17 and 18, if a sensitive differential pressure sensor is to be created for measurement of air pressure. As is shown in Figures 21A – 21C, a semiconductor pressure sensor device for the measurement of air pressure has a semiconductor pressure sensor chip 50 for measuring the air pressure, a circuit frame 200 attached to the semiconductor pressure sensor chip 50, a base 70 upon which the circuit frame 200 is attached, and a cap 80 that sits upon the circuit frame 200 above the circuit frame 200 and the semiconductor pressure sensor chip 50. Two cavities to measure the air pressure are formed by the base 70, the cap 80 and the attachment section 20 located in the circuit frame 200. Pressure inlets A and B are provided as shown individually in Figure 21C. The pressure arriving through the pressure inlet A is fed into the cavities A1 and A2, as is shown in Figure 21A. The pressure entering the pressure inlet B is fed into the cavities B1 and B2, as is

shown in Figure 21B. Due to the separate measurement of pressure by two pressure sensor chips 50, the measuring accuracy is improved in comparison to a measurement with only one pressure sensor chip 50. In a semiconductor pressure sensor device with this kind of configuration, a method is used for attachment of the base 70 and of the cap 80 to the circuit frame 50 [sic], where the semiconductor pressure sensor chip 50 is attached. However, there was the problem that the adhesive resin for attachment of the base 70 and of the cap 80 to the circuit frame 50 [sic] to the side of the semiconductor pressure sensor chip will flow and adhere to the semiconductor pressure sensor chip 50. This deteriorates the properties of the semiconductor pressure sensor chip 200.

The attachment section 20 of the circuit frame 200 is not symmetrically supported by the outer frame of the circuit frame 200 or by any of the inner lines 5, as is shown in Figure 17. If the circuit frame 200 is attached to the base 70, as is shown in Figure 21A, in which an adhesive resin of high viscosity is used as adhesion agent, then the problem resulted that the section not supported by the attachment section was elevated by the adhesive resin applied to the surface of the base 70. This lead to the problem that it was difficult to bond the attachment section 20 to the base 70 horizontally. A fixed tension device had to be used to attach the attachment section 20 to the base 70 to solve the above problem so that the manufacturing method became more complicated.

Since the two attachment sections 20 have a separate placement as indicated in Figure 17, there was also the problem that the physical continuity could not be maintained if the deformation is considered that the two semiconductor pressure sensor chips 50 are exposed to when an external force is exerted on the circuit frame 200. In the case where the semiconductor pressure sensor devices of Figures 21A to 21C are used as accuracy differential pressure sensors, it was necessary to provide the two semiconductor pressure sensor chips 50 inside of two sealed cavities, where the separate section between the two double connection surfaces of Figure 17 had to be sealed with an adhesive resin in a later step. The sealing property, however, could not be improved, since there was a difference in the thickness of the adhesive resin at the separated section and the attachment section.

Therefore it is the purpose of the invention to create a semiconductor pressure sensor device that does not have the above disadvantages and that will provide a more accurate measurement of pressure.

This problem is solved by a semiconductor pressure sensor device with the properties of Claim 1. This device contains a fixed intermediate layer that is formed from a flexible material with a preset thickness, and that absorbs a thermal disturbance generated between the semiconductor and the circuit frame, and for attachment of the semiconductor to the side of the circuit frame, a pressure resistant protrusion located at a site that corresponds to the electrodes of

the semiconductor on the circuit frame, makes it easier to absorb the force produced by the applied pressure from the base of the semiconductor when the electrode and the fine wire are connected together, and a supporting protrusion that is provided at a preset location of the circuit frame is intended to prevent the torsion stresses due to the pressure resistant protrusion from being transferred to the pressure sensor of the semiconductor.

During operation, a fixed intermediate layer with a preset thickness is provided at the attachment position of the semiconductor pressure sensor chip to the circuit frame for attachment of the semiconductor pressure sensor chip to the side of the circuit frame, where the semiconductor pressure sensor chip is secured to the locked intermediate layer and the locked intermediate layer is made of a flexible material, and the circuit frame can absorb and relax the thermal difference in tension between the pressure sensor chip that is attached to the circuit frame. The thermal stress acting between the circuit frame and the semiconductor pressure sensor chip is relieved. A pressure resistant or stress resistant protrusion is provided at a site that corresponds to the electrode of the semiconductor pressure sensor chip of the circuit frame, to absorb the force exerted by the pressure from the bottom of the semiconductor pressure sensor chip when the electrode and the fine metal wire are connected. The supporting section is located at a preset position, so that it will prevent a torsion stress due to the pressure resistant protrusion from being transferred to the pressure sensor of the semiconductor pressure sensor chip. Therefore, the force exerted by the pressure during joining of the electrode and of the fine metal wire will not be absorbed by the locked intermediate layer. The torsion stress is not generated by the pressure resistant protrusion of the pressure sensor of the semiconductor pressure sensor chip.

According to another embodiment of the invention, a semiconductor pressure sensor device has double connection surfaces (dipads) that are located in the circuit frame where the semiconductor pressure sensor chip is located, and an outer frame provided in the circuit frame is positioned so that a section thereof will connect and support the double connection surface, whereby it has a groove to prevent the flow of resin along a section of the intersection region to the double connection surface.

In operation, a double connection surface is provided in the circuit frame where the semiconductor pressure sensor chip is installed. In addition, an outer frame is provided that has a groove formed along at least one section of the intersection region with the double connection surface to prevent the flow of resin, so that at least one section thereof is joined to the double connection surface and supports it. Therefore, during attachment of the cap and the base over or under the circuit frame, the adhesive resin flowing to the side of the semiconductor pressure sensor chip runs into the groove to prevent the flow of resin.

According to another embodiment of the invention, the semiconductor pressure sensor device has attachment sections provided in the circuit frame for attachment of the semiconductor

pressure sensor chip and an outer frame located in the circuit frame for joining and for diagonal support of the attachment section to at least two sites. In operation, the attachment section is provided in the circuit frame where the semiconductor chip sensor is located. An outer frame is provided in the circuit frame to join and to support the attachment section to at least two sites. Thus, the attachment section is supported symmetrically to prevent the semiconductor pressure sensor device from being elevated from the circuit frame by the adhesive resin when the attachment section of the circuit frame is secured to the base, so that the need for a clamping device is eliminated.

According to another embodiment of the invention, a semiconductor pressure sensor device has an attachment section in the circuit frame where the semiconductor pressure sensor chip is attached, and an outer frame is provided in the circuit frame so that at least one section thereof joins and supports the attachment section, whereby they are joined together at the central section between neighboring attachment sections.

In operation, one attachment section in the circuit frame is provided with a semiconductor pressure sensor chip located thereon. An outer frame joined to every other frame at the central section between neighboring attachment sections is provided in the circuit frame so that at least one section thereof will join and support the attachment sections. Therefore, the thickness of the adhesive in the central section, during attachment of a base and a cap to the circuit frame by an adhesive, can be made uniform, and external force will be transferred physically continuously to the two semiconductor pressure sensor chips.

According to another refinement of the invention, a method is proposed for manufacture of a semiconductor pressure sensor device that is characterized by the properties of the patent claim. The method has the following steps: Attachment of a circuit frame to a pressure-resistant protrusion that is formed at a site that corresponds to the electrode of the semiconductor pressure sensor chip, and with a supporting protrusion that is formed at a preset site to keep horizontal the semiconductor pressure sensor chip, whereby for the semiconductor pressure sensor chip a reinforcing intermediate layer is provided at a preset thickness and with the ability to relieve stresses, and pressure mounting of the fine metal wire to the electrode, whereby the bottom thereof is held by the pressure-resistant protrusion.

In operation, a circuit frame with a pressure resistant protrusion is provided that is formed at a position that corresponds to the electrode of the semiconductor pressure sensor chip, and with a supporting protrusion that is formed at a preset position to maintain the horizontal position of the semiconductor pressure sensor chip, and that secures the semiconductor pressure sensor chips to each other by means of a fixed intermediate layer, that has a preset thickness and the ability to relieve tension. The electrode is secured by pressure to a fine metal wire, and the bottom of the electrode of the semiconductor pressure sensor chip is held by the pressure

resistant protrusion. Therefore, the electrode and the fine metal wire can be secured normally, without the force produced by the application of pressure being absorbed by the locked intermediate layer. Likewise, the thermal stress acting between the circuit frame and the semiconductor pressure sensor chip is relieved.

Thus the advantage is attained that no silicon base is needed for attachment of the semiconductor pressure sensor to the circuit frame. This will prevent the adhesive resin, during attachment of a base and a cap to the circuit frame where the semiconductor pressure sensor chip is attached, from adhering to the semiconductor pressure sensor chip, so that the pressure measuring properties would be deteriorated. Connection surfaces can be easily secured horizontally, without having to provide a clamping device in a semiconductor pressure sensor device, since the connecting surfaces of the circuit frame are located at the base. The sealing properties of the cap and of the base that are located above and below the circuit frame, can be improved; the physical uniformity and continuity in the two semiconductor pressure sensor chips can be improved with respect to deformation by external forces in a semiconductor pressure sensor device. The electrodes and the fine wires can be attached at standard pressure, without the force generated by application of pressure causing a pressure on a locked intermediate layer when applying pressure to the electrode and to the fine metal wire in the manufacturing method for a semiconductor pressure sensor device.

Additional properties and advantages of the invention are indicated in the description of design embodiments based on the figures. The figures show:

Figure 1 is an enlarged view of an attachment section according to one embodiment of the semiconductor pressure sensor device

Figure 2A is a schematic view to explain the tensile and flexural moment based on the thermal interference that is produced by the provision of a protrusion for the wire connection for the attachment section shown in Figure 1

Figure 2B is a schematic diagram to explain the tensile and flexural moment due to the supporting protrusion that is used to compensate the tensile and flexural moment that is generated by the protrusion for the wire connection of the attachment section shown in Figure 1,

Figure 3 is a top view of one design embodiment of the circuit frame where the semiconductor pressure sensor chip of Figure 1 is attached,

Figure 4 is a side view of the circuit frame of Figure 3,

Figure 5 is an enlarged cross sectional view of the attachment section of the circuit frame of Figure 3,

Figures 6A and 6B are cross sectional views to explain the manufacturing steps for the semiconductor pressure sensor device of figure 1,

Figure 7 is a cross sectional view of the configuration of the semiconductor pressure sensor device of Figure 6B that is used to measure air pressure,

Figure 8 is a top view of a circuit frame of a second design embodiment,

Figure 9 is a top view of a circuit frame of a third design embodiment

Figure 10 is a top view of a circuit frame of a fourth design embodiment

Figure 11 is a top view of a circuit frame of a fifth design embodiment

Figure 12 is a top view of a conventional semiconductor pressure sensor chip

Figure 13 is a side view of the semiconductor pressure sensor chip from Figure 12

Figure 14 is a cross sectional view of the semiconductor pressure sensor chip of Figure 12 along plane B-B,

Figure 15 is a top view of a circuit frame with a conventional semiconductor pressure sensor device,

Figure 16 is a side view of the circuit frame of Figure 15,

Figure 17 is a top view of a completed semiconductor pressure sensor device with a semiconductor pressure sensor chip attached to the circuit frame of Figure 15,

Figure 18 is a side view of the semiconductor pressure sensor device of Figure 17,

Figure 19 is an enlarged, partial view along line C-C of the attachment section of the semiconductor pressure sensor device of Figure 17,

Figure 20 is a schematic diagram to explain the tensile and flexural moments produced in the semiconductor pressure sensor chip of Figure 19,

Figures 21A and 21B are cross sectional views of the configuration of a semiconductor pressure sensor device with cavities to measure air pressure, and

Figure 21C is a top view of the semiconductor pressure sensor device of Figure 21A and 21B without the cap.

With reference to Figures 1 to 5 the structure of an attachment section 1 of a circuit frame 100 will be explained below. The attachment section 1 of the circuit frame 100 has a concave section or a basin-shaped section 2 to form an adhesive layer with a preset thickness to secure a semiconductor pressure sensor chip 50, a protrusion or protruding section 4 for wire-connecting the associated electrode 53 to hold the base of the semiconductor pressure sensor chip 50 when applying the pressure of a fine metal wire to the electrode of the semiconductor pressure sensor chip 50, a supporting protrusion 11 to compensate the tensile moment and flexural moment that is produced by the protrusion 4 holding the wire connection, and a pressure relief opening 3 that is provided like a diaphragm unit 54 of the semiconductor pressure sensor chip 50.

In the concave section 2 of the attachment section 1 there is an adhesive 10 with a preset thickness to provide the adhesion effect. A silicon-like resin or a silicone like resin with the ability to relieve tension is used as material for the adhesive. The circuit frame 100 of Figure 3

has a concave section 2, a pressure relief opening 3, an attachment section that is formed by a wire connector protrusion 4 and a supporting protrusion 11, an inner line 5 for wire joining of the electrode of the pressure sensor chip 50 and the fine metal wire for attachment of the semiconductor pressure sensor chip 50 to the circuit frame 100, an immersion element 6 and an outer line 7.

The circuit frame 100 is provided with etched zones E1 to E4. The etched zone E1 is provided to hold the adhesive 10 of Figure 7 for the adhesion effect and corresponds to the concave section 2. The thickness of the adhesive 10 (see Figure 1) can be ensured by the etching zone E1. The etching zone E2 is intended for the purpose of resin antiflow such that excessive adhesive resin will be prevented from flowing over from the adhesive region of the cap to be attached to the semiconductor pressure sensor chip 50 (see Figure 1) when the cap is secured to the circuit frame 100. It also performs the task of transferring external loads from the cap via the circuit frame 10 and the adhesive 10 (see Figure 1). The etching zone E3 is used to reduce the externally transferred load via the suspension conductor (inner conductor 5). Etching zone E4 is the resin antiflow groove to prevent excess adhesive resin from flowing off during attachment of the cap to the circuit frame 100. Even though all the etching zones E1 to E4 are used in the present design embodiment, the invention is not restricted to this feature. The etched zones can be provided in the combination required.

The tensile moments and flexural moments in Figures 2A and 2B are for the case in which only the protrusion 4 holding the wire connection is used, and for the case when the supporting protrusion 11 is also used to compensate the tensile and pressure moments produced by the protrusion 4 holding the wire connection as shown. As is shown in Figure 2A in which only the pressure resistant protrusion 4 is shown, the tensile moments F2, F100 and F101 are produced, while the flexural moments M2, M100, M101 and M102 are produced. The equilibrium state of the forces in the case of thermal stress generation is described by the following equations (5) and (6):

$$F_{31} + F_{101} + F_{100} + F_2 = 0 \quad (5)$$

$$M_{53} + M_{102} + M_{101} + M_{100} + M_2 = 0 \quad (6)$$

A comparison of these equations (5) and (6) with equations (1) and (2), that are used to explain the state of the conventional semiconductor pressure sensor chip of Figure 15, shows that F30 and F20 from equation (1) correspond to F100 or F2 of equation (5), while M30 and M20 from equation (2) correspond to M100 or M2 of equation (6). The new tensile and flexural moments produced by the provision of the protrusion 4 to hold the wheel connection are F100,

M100 and M102. For a compensation of the tensile moment F100 and the flexural moments M101 and M102, a supporting section 11 is provided in the present design embodiment, as is shown in Figure 2B. Due to the provision of this supporting section 11, the tensile moment F51 and the flexural moment M51 that appear at the pressure sensor 51 of the semiconductor pressure sensor chip 50, are represented by the following equations (7) and (8):

$$F_{51} = -(F_{102} + F_{101} + F_{100} + F_2) \quad (7)$$

$$M_{51} = -(M_{104} + M_{103} + M_{102} + M_{101} + M_{100} + M_2) \quad (8)$$

The supporting protrusion 11 is positioned so that the flexural moment M104 of equation (8) takes on the value expressed by the equation (9):

$$M_{104} = -(M_{103} + M_{102} + M_{101} + M_{100} + M_2) \quad (9)$$

The arrangement of the supporting section 11 explained above yields M51 = 0 in equation (8). That is, the flexural moment exerted on the pressure sensor 51 can be made to 0. The supporting protrusion 11 can also be positioned so that the value of the flexural moment M51 on the pressure sensor 51 is not 0, but rather an arbitrarily selected value. In this case it is possible to employ the semiconductor pressure sensor device so that a preset flexural moment at the pressure sensor 51 of the semiconductor pressure sensor chip 50 will eliminate the offset value that the semiconductor pressure sensor chip 50 itself has.

Now with reference to Figures 1, 6A and 6B, hereinafter the manufacturing steps are described. The attachment section 1 of the circuit frame 100, that is provided with the protrusion 4 to hold the wire connection and with the supporting protrusion 11, is placed onto a connecting device 700. The adhesive 10 formed from a silicon-like resin for connecting of the [is] brought into the concave section 2 of the attachment section 1. The semiconductor pressure sensor chip 50 is bonded with the supplied adhesive 10 by adhesion. Next, the inner line 5 and the electrode 53 of the semiconductor pressure sensor chip 50 are wire joined by a fine metal wire 15, as is shown in Figure 6B. The force absorbed by the semiconductor pressure sensor chip 50 due to exertion of pressure with the application of pressure of the fine metal wire 15 to the electrode 53, is absorbed by the protrusion 4 provided in the concave section 2 to hold the wire connection. The electrode 53 can be brought up without absorbing the pressure exerted by the connecting adhesive 10. Thus, the attachment section 1 of the semiconductor pressure sensor device of Figure 1 is completed. Between the semiconductor pressure sensor chip and the attachment section 1 there is the adhesive 10 with uniform thickness and the ability to relieve stress. The

thermal stress produced on the pressure sensor 51 of the semiconductor pressure sensor chip 50 is diminished to improve the measuring accuracy of the semiconductor pressure sensor device. Using this method, it is not necessary to provide a silicon base made of silicon monocrystal between the semiconductor pressure sensor chip 50 and the attachment section 1. Therefore, an increase in the manufacturing costs and in the complicated production steps of using the silicon base can be avoided.

According to the semiconductor pressure sensor device and the manufacturing method according to this design embodiment, the attachment section 1 of the circuit frame 100 is provided with a concave section 2, a protrusion 4 to hold the wire connection, and a supporting protrusion 11, so that the joining and wire connecting can be carried out by the usual production steps, as are common for integrated circuits. Therefore, an adhesive layer of a flexible material that can reduce stresses and that has a preset thickness, can be formed, so that the wire connection can be carried out on the basis of its thickness. Even though a resin of the silicon type is used as the bonding adhesive 10 in the present design embodiment, this is only an example and any adhesive can be used that is able to relieve tension or stresses. Even though the stress reducing property with an adhesive has been introduced in the present design embodiment, the invention is not limited by this property, and the stress relieving property can be provided by rubber or similar material, for example, by placing an adhesive on both sides of a flexible material such as rubber. A resin antiflow groove is used by the provision of a concave section in the attachment section of the circuit frame to achieve a thick adhesive layer in the present design embodiment. However, similar results can be achieved by forming the connecting material with a tape with a preset thickness, instead of the adhesive. The provision of a concave section in the attachment section makes possible the formation of a thick adhesive layer. This has the advantage of improving the absorption of external stress and of absorbing thermal stresses of the attachment sections and of the semiconductor pressure sensor chip in comparison to conventional methods.

As is shown in Figure 7, a cavity that represents the pressure measurement chamber is formed by a base 70 and a cap 80 in the case that an application for measurement of air pressure is selected. The measurement of pressure with a configuration of this kind has a high accuracy with conventional semiconductor pressure sensor devices, since the load-resistant protrusion 4, the supporting protrusion 11 and the connecting adhesive 10 are used to reduce the stresses in the semiconductor pressure sensor device in the present design embodiment.

In the design embodiment shown in Figure 8, an etched zone E5 is shown along the interface zone of the attachment section 1 and a suspension 100a of the frame 100 to support the attachment section 1. When using a semiconductor pressure sensor device with a pressure measurement chamber (cavity) of Figure 7, an etched zone of this kind E5 can make the

thickness of the adhesive more uniform to improve the sealing activity. In addition, the adhesion of excessive adhesive resin to the semiconductor pressure sensor chip 50 at the time of attachment of the base 70 and of the cap 80 can be prevented so that the pressure sensor properties will not be deteriorated.

In the design embodiment shown in Figure 9, the attachment section 1 is supported by a different suspension 100b in addition to the above suspension 100a. Due to the symmetrical support of the attachment section 1 in the above manner, the problem mentioned above of elevation of the attachment section 1 when R is secured to the base 70, can be solved since the used adhesive has such a high viscosity that the attachment section 1 can be brought up horizontally without having to use a clamping device.

In the design embodiment shown in Figure 10, suspensions 100a are used to support neighboring attachment section 1 by a central connection 100c in the central section between the attachment section 1. Due to this configuration, the problem is solved that occurs with the semiconductor pressure sensor device of Figure 7, that the sealing property is reduced in the central section between the attachment section 1 during attachment of the base 70 and of the cap 80. According to the present design embodiment, likewise the problem is solved that the physical unit in the deformation of the two chips is eliminated when an external force is exerted on the frame 100 in conventional devices, in which the central section is separated. Consequently, the measuring accuracy of the semiconductor pressure sensor device is improved.

The design embodiment shown in Figure 11 is a combination of the third design embodiment of Figure 9 and the fourth design embodiment of Figure 10. The attachment section 1 can be brought up horizontally to the base 70 (see Figure 7), without having to use a clamping device, since in addition to the suspension 100a, the suspension 100b is used to support the attachment section 1. In addition, since the center section between the attachment section 1 is bonded by the central bond 100c, the physical unit can be maintained by external forces with respect to the deformation, likewise the sealing property of the cavities can be improved. Even though the design embodiments in Figures 8 to 10 each show one example wherein a new structure is used, the design embodiments of Figures 8 to 10 can also be used in combination, should this be necessary.

With regard to the semiconductor pressure sensor device with the cavity built into the circuit frame 100 of Figure 8, the formation of a groove-like etched zone E5 along the interface region of the suspension 100a that supports the attachment section 1, and the attachment section 5 that excess resin flows and adheres to the side of the semiconductor pressure sensor chip when the base 70 and the cap 80 are brought to the circuit frame 100, since the resin runs into the etched zone E5 [sic]. In addition, since the region to form the etched zone E5 is pressed to a

minimum, the thickness of the adhesive layer is more uniform for application of the base 70 and the cap 80 to the circuit frame 100, so that the sealing property is improved.

With regard to the semiconductor pressure sensor device with the cavity located at the circuit frame 100 in Figure 9, the attachment section 1 is additionally supported by the suspension 100b in addition to a conventional suspension 100a. Therefore, the attachment section 1 will not be lifted when the circuit frame 100 is placed on the base 70, even if the adhesive provided on the surface of the base 70 has a high viscosity. The attachment section 1 of the circuit frame 100 can be supplied horizontally to the base 70 without a clamping device.

With regard to the semiconductor pressure sensor device with a cavity in which the circuit frame 100 of Figure 10 is used, suspensions 100a are provided to hold the attachment section 1 by a central connector 100c to the central site between neighboring circuit frames 1. The thickness of the adhesive at the central section is likewise equal to that of the other sections, so that the sealing property of the cavity is improved. If an external force is exerted onto the circuit frame 100, then the connection at the central section causes a physical uniformity or continuity of the deformations transferred to the circuit frame 1, where two semiconductor pressure sensor chips 50 are located.

Now in the method for production of the semiconductor pressure sensor device of Figures 6A and 6B, the applied force absorbed by the semiconductor pressure sensor chip 50 is absorbed by the protrusion 4 to hold the wire connector that is located in the concave section 2. The force absorption takes place through the bottom of the semiconductor pressure sensor chip 50 at the corresponding site of the electrode 53 when the fine metal wire 15 is connected to the electrode 53 under pressure. The force exerted by the application of pressure is not absorbed by the bonding adhesive 10 during the time in which pressure is exerted on the electrode for bonding. The bonding adhesive 10 has the ability to relieve stress, and has a uniform thickness between the semiconductor pressure sensor chip 50 and the connecting section 1, and it can be used to relieve thermal pressure generated in the pressure sensor 51 of the semiconductor pressure sensor chip 50, so that the measurement accuracy of the semiconductor pressure sensor device is improved.

According to the design of the present invention, therefore, a locked intermediate layer with a preset thickness is secured to the attachment position of the semiconductor pressure sensor chip of the circuit frame in order to secure the semiconductor pressure sensor chip to the side of the circuit frame. The semiconductor pressure sensor chip is secured to the locked intermediate layer. By the use of the locked intermediate layer made of a flexible material, the thermal distortion differences that are formed between the semiconductor pressure sensor chip and the circuit frame are absorbed and relieved. Thus, the thermal stress acting between the circuit frame and the semiconductor pressure sensor chip is relieved, so that the measurement accuracy of the

semiconductor pressure sensor device is improved, without a silicon base being needed. Due to the provision of the stress-reducing protrusion at a position corresponding to the electrode of the semiconductor pressure sensor chip, to absorb the pressure application force from the bottom of the semiconductor pressure sensor chip, and also by provision of a supporting protrusion at a preset position so that the distortion stress is not transferred to the pressure sensor of the semiconductor pressure sensor chip due to the thermal distortion, the force of pressure application is not absorbed by the locked intermediate layer at the moment when the electrode and the fine metal wire are pressed securely to each other with pressure. Since the distortion stress emanating from the stress-resistant protrusion is not generated at the pressure sensor of the semiconductor pressure sensor chip, the thermal stress occurring between the circuit frame and the semiconductor pressure sensor chip will be adjusted by the locked intermediate layer, the stress reducing protrusion and the supporting protrusion so that the measuring accuracy of the semiconductor pressure sensor device is improved.

According to another embodiment of the invention, the circuit frame is equipped with an attachment section in which the semiconductor pressure sensor chip is supplied, and with an outer frame that has a resin antiflow groove in at least one section of the transition zone to the attachment section, so that at least one section thereof will join and support the attachment section. The adhesive resin flowing to the side of the semiconductor pressure sensor chip during attachment of the cap and base above and below the circuit frame, respectively, runs into the resin antiflow groove. This prevents the adhesive resin from adhering to the semiconductor pressure sensor chip when the base and the cap are joined to the circuit frame where the semiconductor pressure sensor chip is located. Therefore, the quality of the pressure measurement is not adversely affected in this semiconductor pressure sensor device.

According to yet another design embodiment of the invention, the circuit frame is equipped with attachment sections where the semiconductor pressure sensor chip is located, and with an outer frame for joining and supporting the attachment section diagonally on at least two sites. The attachment sections are symmetrically supported to prevent the attachment sections from lifting off the circuit frame due to the adhesive resin during application of the base; thus the need for an attachment clamping device is eliminated. The attachment section can be easily brought on horizontally without the use of an attachment device.

According to another design embodiment of the invention, the circuit frame is equipped with attachment sections where the semiconductor pressure sensor chip is located, and with an outer frame that is connected to the two attachment sections neighboring between the central section, so that at least one section of the frame joins and supports the attachment sections. The thickness of the adhesive at the central section is made uniform with an adhesive during attachment of the base and the cap to the circuit frame. External force is transferred uniformly to

the two semiconductor pressure sensor chips. Therefore, the sealing property of the cap and base attached above or below the circuit frame is improved. The physical continuity with respect to deformation by external force is introduced by the two continuous semiconductor pressure sensor chips.

According to another design embodiment of the invention, a circuit frame is provided with a pressure-resistant protrusion that is formed at a position that corresponds to the electrode of the semiconductor pressure sensor chip, and with a supporting protrusion at a preset position to keep horizontal the semiconductor pressure sensor chip, and is joined together with a semiconductor pressure sensor chip by means of a locked intermediate layer with a preset thickness and that has the ability to relieve stress. By pressure attachment of a fine metal wire to the electrode, whereby the base of the electrode of the semiconductor pressure sensor chip is held by the pressure resistant protrusion, the electrode and the fine metal wire can be joined together by pressure, without the pressure being absorbed by the locked intermediate layer. Thus, the thermal stress acting between the circuit frame and the semiconductor pressure sensor chip can also be relieved.

<u>Claims</u>

1. Semiconductor pressure sensor unit with:

- a semiconductor pressure sensor chip (50) with a semiconductor substrate, a pressure sensor (51) to determine the pressure,

an amplifier circuit (52) to boost the signal from the pressure sensor (51), and

at least one electrode (53) formed on the semiconductor substrate;

- a circuit frame (100) for attachment of the semiconductor pressure sensor chip (50),

- characterized by

- a locked intermediate layer (10) formed from an elastic material with a preset thickness for absorption and relaxation of thermal differences in torsion produced between the semiconductor pressure sensor chip (50) and the circuit frame (100) for attachment of the semiconductor pressure sensor chip (50) to the side of the circuit frame (100);

- a load-resistant protrusion (3) that is located at a site corresponding to the electrode (53) of the semiconductor pressure sensor chip (50) of the circuit frame (100) to absorb the force exerted by the pressure from the base of the semiconductor pressure sensor chip (50) during the application of pressure of a fine metal wire (15) to the electrode (53);

- a support protrusion (11) provided at a preset location of the circuit frame (100) to prevent the torsion stress generated by the load-resistant protrusion (4) from being transferred to the pressure sensor (51) of the semiconductor pressure sensor chip (50).

2. Semiconductor pressure sensor unit according to Claim 1, characterized in that the circuit frame (100) has:

- an attachment section (1) for attachment of the semiconductor pressure sensor chip (50), where the locking intermediate layer (10) is located in between;

- an outer frame that is provided so that at least one section thereof joins and supports the attachment section (1), and has at least one section (E2) of the joined region with the attachment section (1) formed in a concave manner

- a line (5) electrically connected to the electrode (53) of the semiconductor pressure sensor chip (50), that is provided so that at least one line (5) joins and supports the connecting section (1) and has a connection region (E3) with the connecting section (1) formed in a concave manner.

3. Semiconductor pressure sensor unit according to Claim 2, characterized in that the outer frame has an outer frame with a resin antiflow groove (E4) that is formed in at least one section of a region that is not the region that is formed in a concave manner.

4. Semiconductor pressure sensor unit according to the preamble of Claim 1, characterized by

- a connecting section (2) provided in the conductor frame (100) to attach the semiconductor pressure sensor chip (50), and

- an outer frame provided in the conductor frame (100), so that at least one part of the connecting section is connected and supported, and has a resin antiflow groove (E5) that is formed along at least one section of the intersection region with the reinforcing section (1).

5. Semiconductor pressure sensor unit according to the preamble of Claim 1, characterized by

- an attachment section (1) located in the circuit frame (100) for attachment of the semiconductor pressure sensor chip (51) and

- an outer frame located in the circuit frame (100) for connecting and supporting the connecting section (1) diagonally at least at two sites (100a, 100b).

6. Semiconductor pressure sensor unit according to the preamble of Claim 1, characterized by

- a connecting section (1) located in the circuit frame (100) for attachment of the semiconductor pressure sensor chip (50) and

- an outer frame located in the circuit frame (100) so that at least one section thereof connects and joins the connecting section (1), and joins two neighboring connection sections (1) to each other at the central section (100c).

7. Semiconductor pressure sensor unit according to one of the Claims 2 to 6, characterized in that the connecting section (1) has a connecting section (1) with a region (E1)

where the locking intermediate layer (10) is secured, that is formed in a concave manner, where the semiconductor pressure sensor chip (50) is located, and that is provided with a pressure resistant protrusion (4) and a supporting protrusion (11) at preset positions for stress relief.

8. Semiconductor pressure sensor unit according to one of the Claims 1 to 7, characterized in that a number of electrodes (53) is provided.

9. Method for production of a semiconductor pressure sensor unit with a semiconductor pressure sensor chip (50) with electrodes (53) and a circuit frame (100) for attachment of the semiconductor pressure sensor chip (50), where the production method is characterized by the following steps:

- attachment of the circuit frame (100) with a pressure resistant protrusion (4) that is formed at a site corresponding to an electrode (53) of the semiconductor pressure sensor chip (50), and with a supporting section (11) that is formed at a preset location for horizontal holding of the semiconductor pressure sensor chip (50), to the semiconductor pressure sensor chip (50), where a locking intermediate layer (10) with a preset thickness and the potential to relieve stress is located in between, and
- application of pressure from a fine metal wire (15) to the electrode (53), wherein the bottom of the electrode (53) is supported by the pressure-resistant protrusion (4).

FIG.1

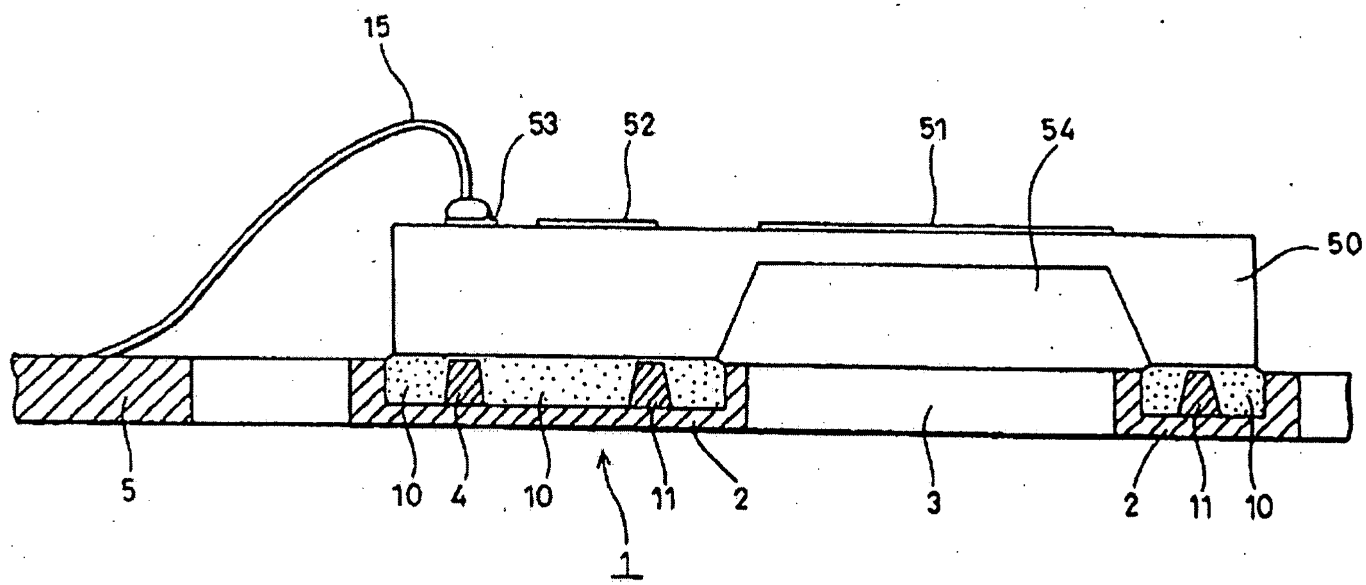


FIG.2A

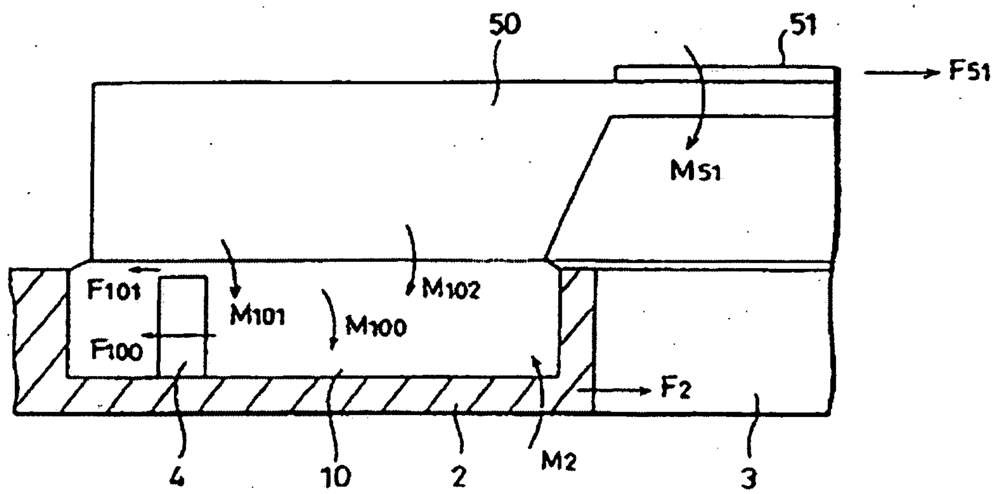

50
51
F51
M51
M101
M102
F101
M100
F100
F2
4
10
2
M2
3

FIG.2B

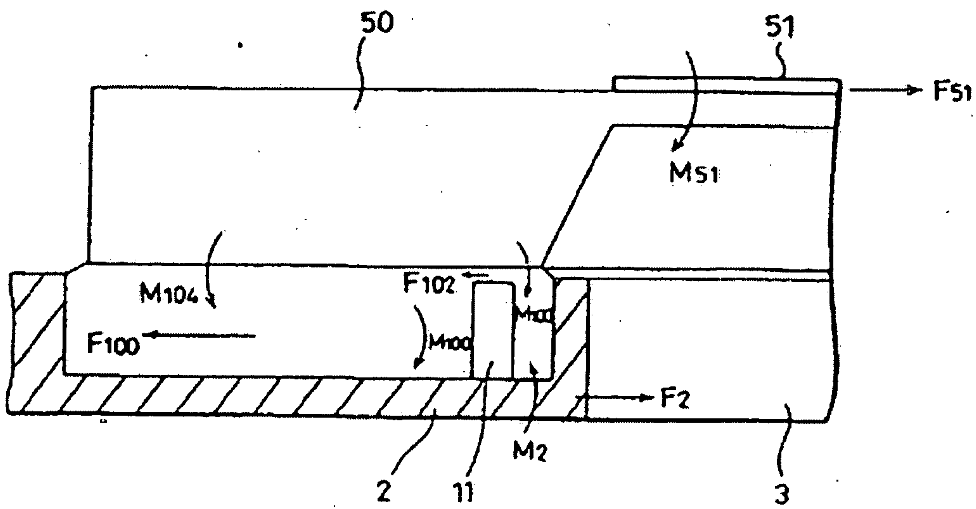

50
51
F51
M51
M104
F102
F100
F2
2
11
M2
3

FIG. 3

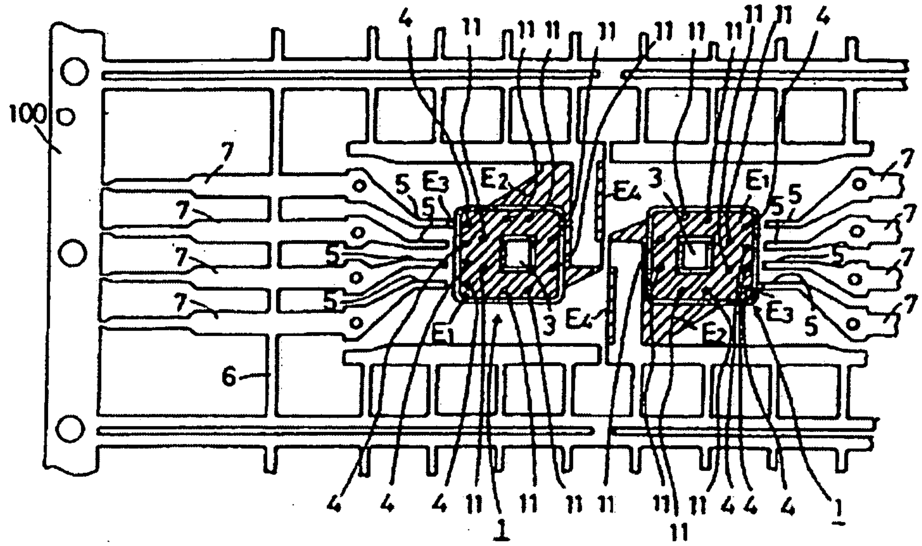


FIG. 4

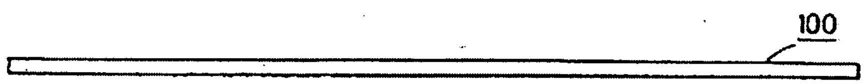


FIG.5

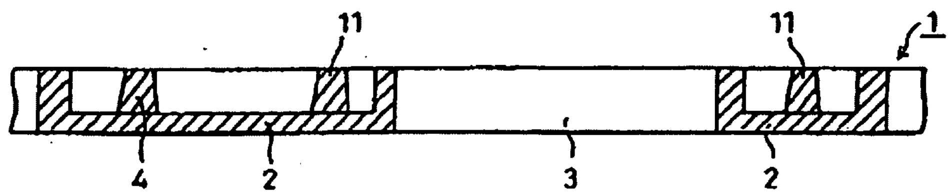


FIG.6A

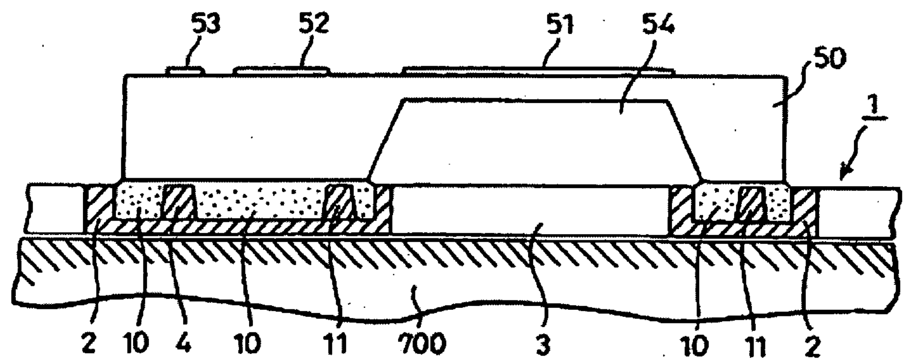


FIG.6B

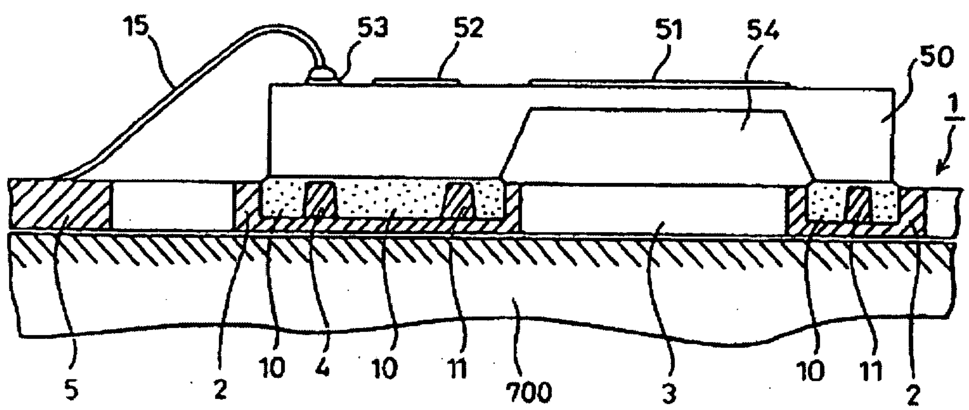


FIG. 7

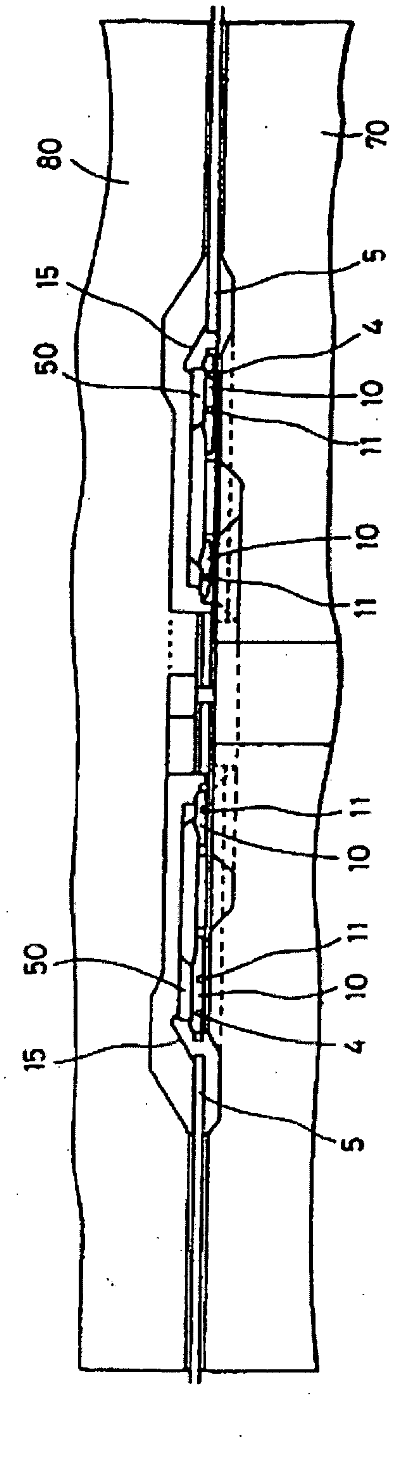


FIG. 8

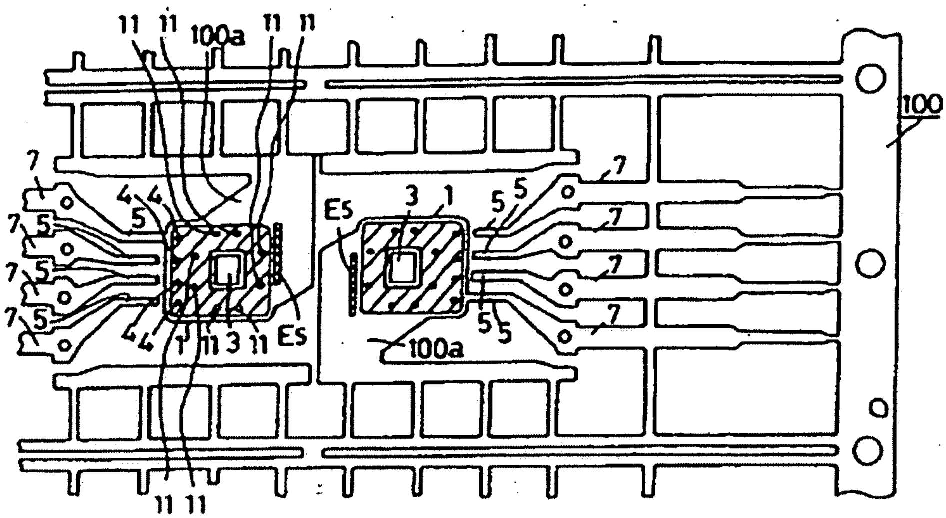

11 11 100a 11 11
100
7
4 4
5
3 1
5 5
Es
7
7 5
7 5
7 5
7
7
4 4 1 11 3 11 Es
5 5
100a
11 11

FIG. 9

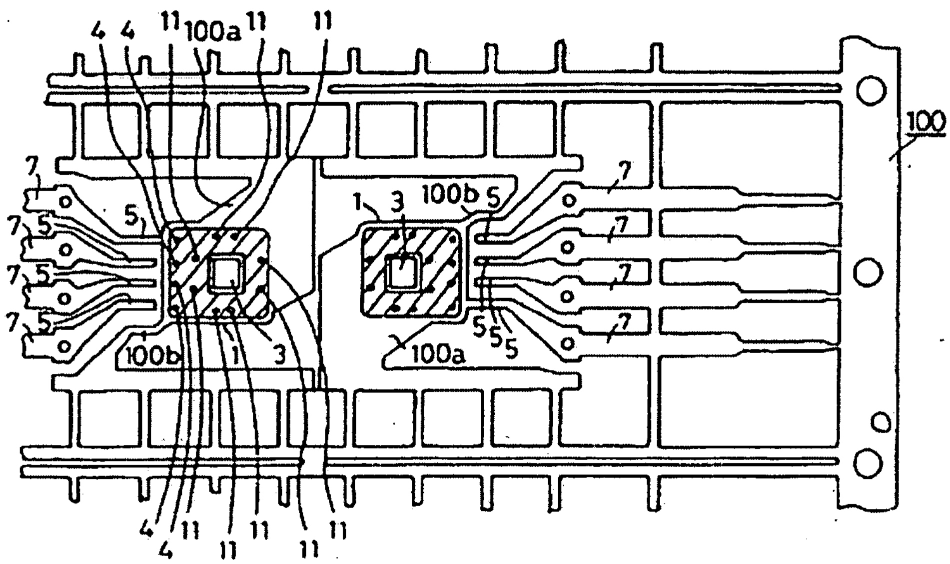

4 4 11 100a 11 11
100
7
7 5
7 5
7 5
5
1 3 100b 5
7
7
7
7
100b 1 3
100a
5 5 5
4 11 11 11
4 11 11 11

FIG.10

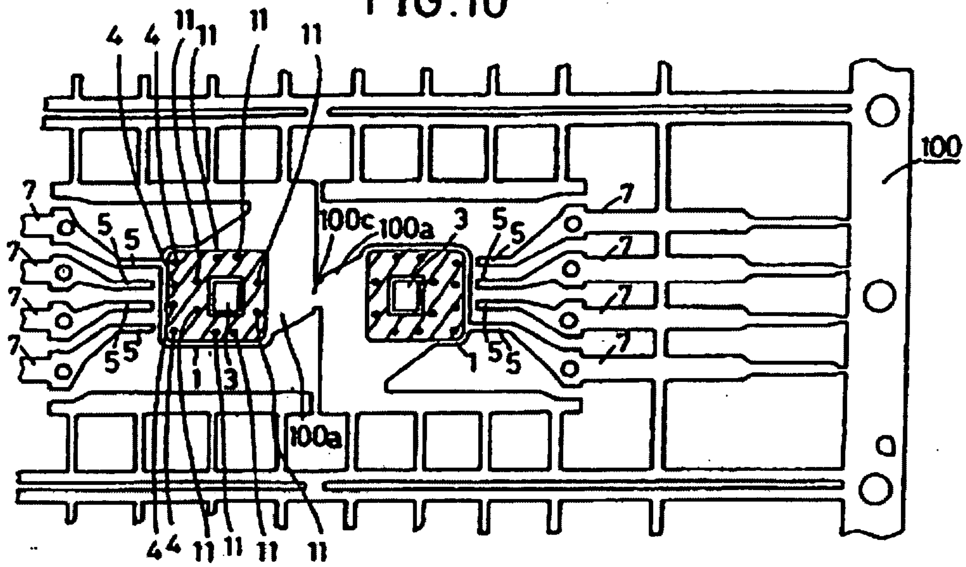

4
4
11
11
11
11
7
7
7
7
5
5
5
5
100c
100a
3
5
5
100
7
7
7
7
1
3
1
5
5
100a
4
4
11
11
11
11

FIG.11

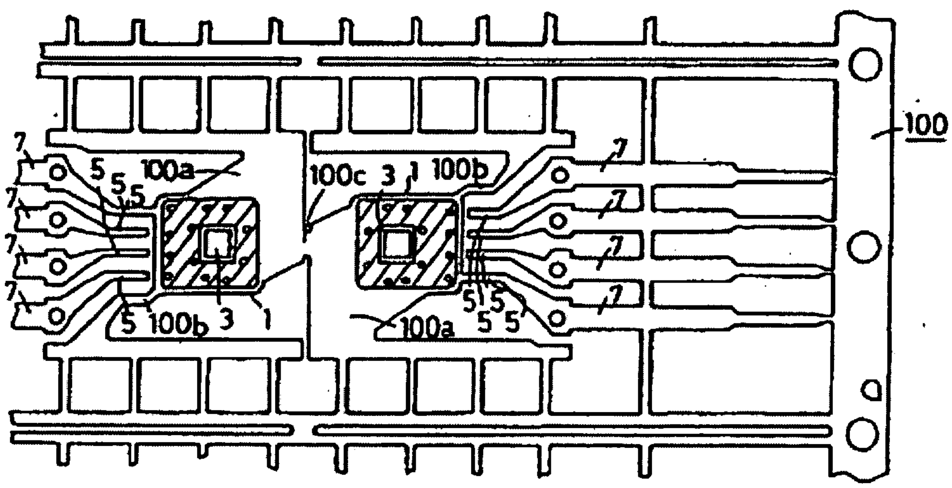

100
7
7
7
7
5
5
5
100a
100c
3
1
100b
7
7
7
7
5
100b
3
1
100a
5
5
5
5

FIG. 12

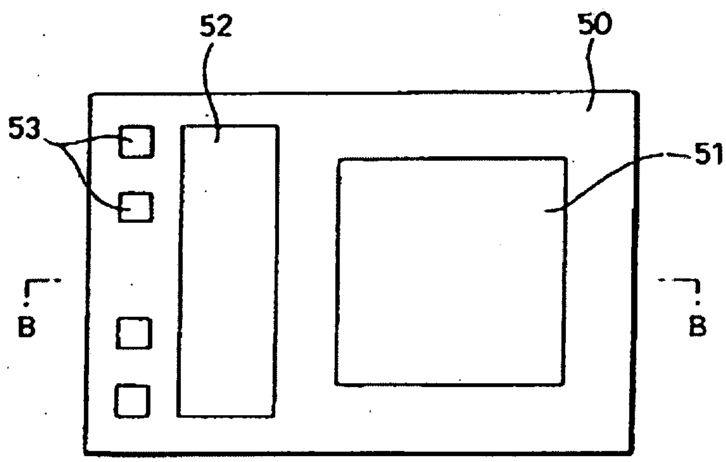


FIG. 13

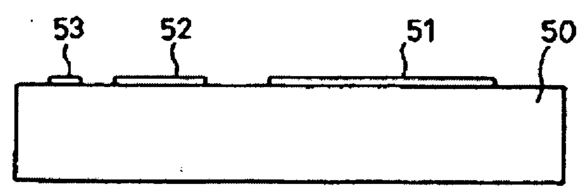


FIG. 14

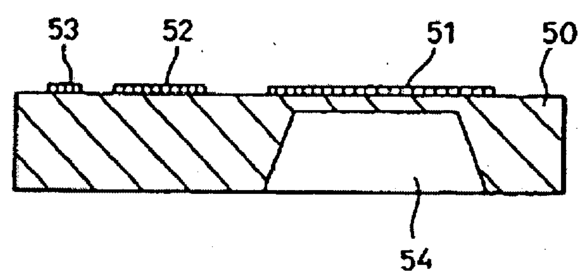


FIG. 15

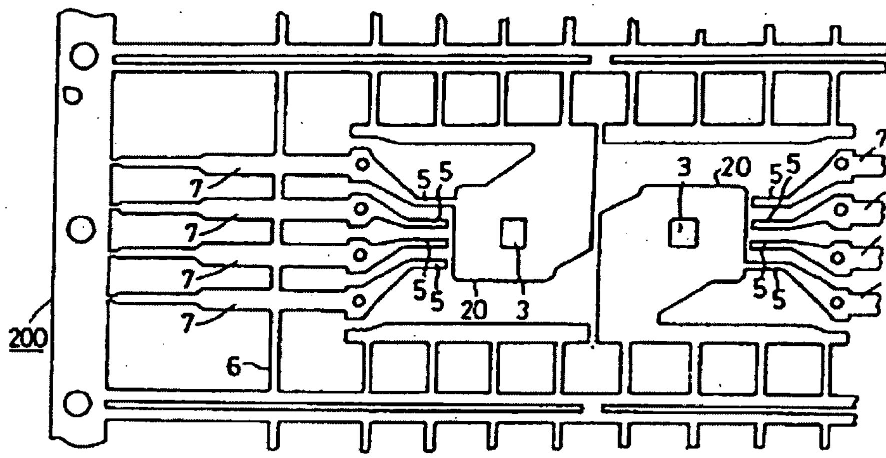


FIG. 16

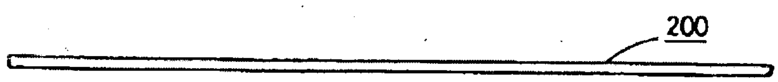


FIG. 17

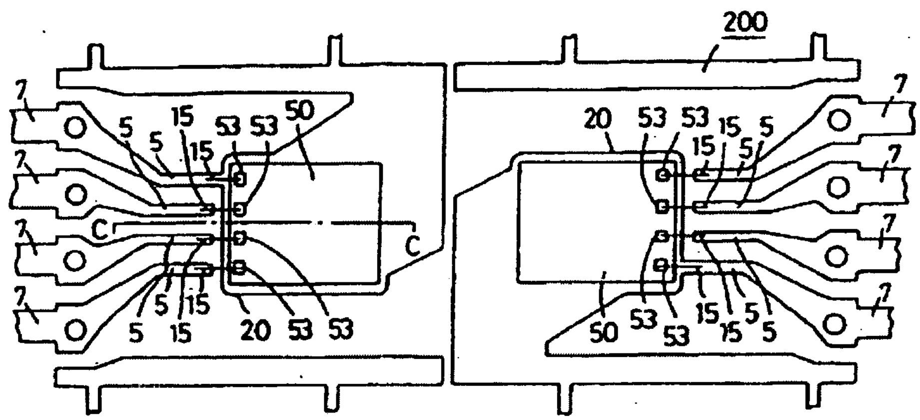

200
7
7
7
7
5
5
15
15
53
53
50
C
C
5
15
5
15
20
53
53
20
53
53
15
15
5
5
7
7
7
7
50
53
53
15
15
15
5
5

FIG. 18

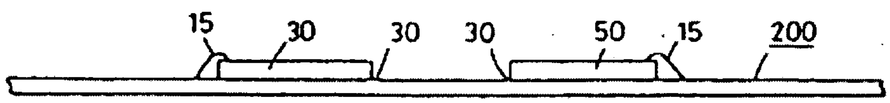

15
30
30
30
50
15
200

FIG. 19

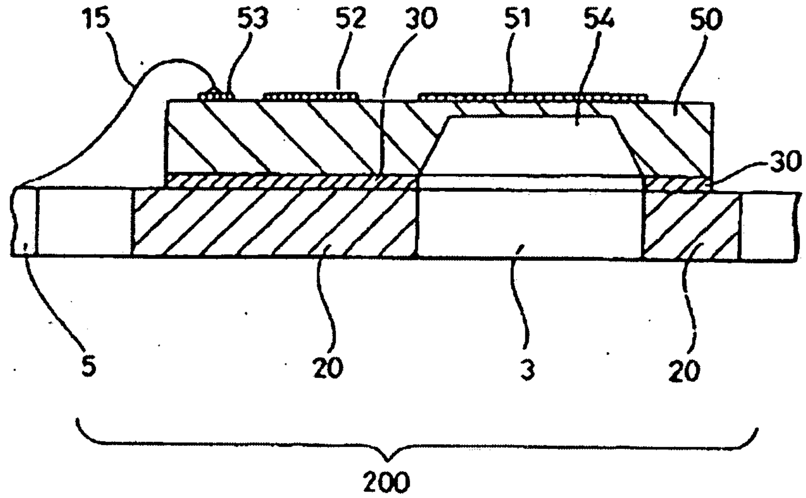
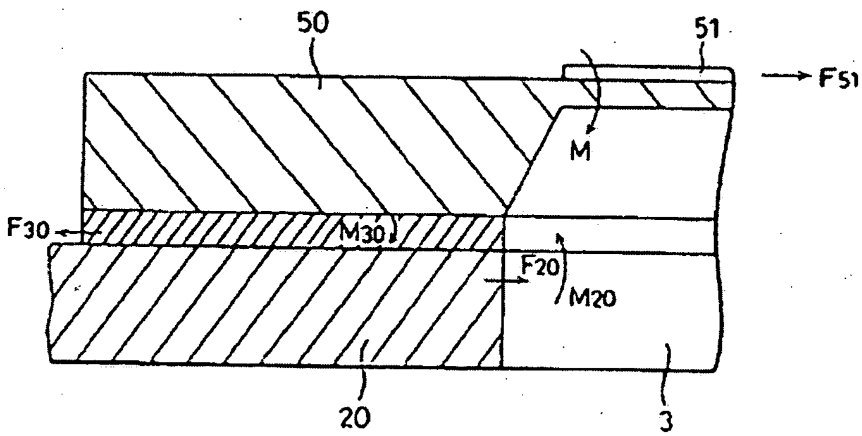


FIG. 20



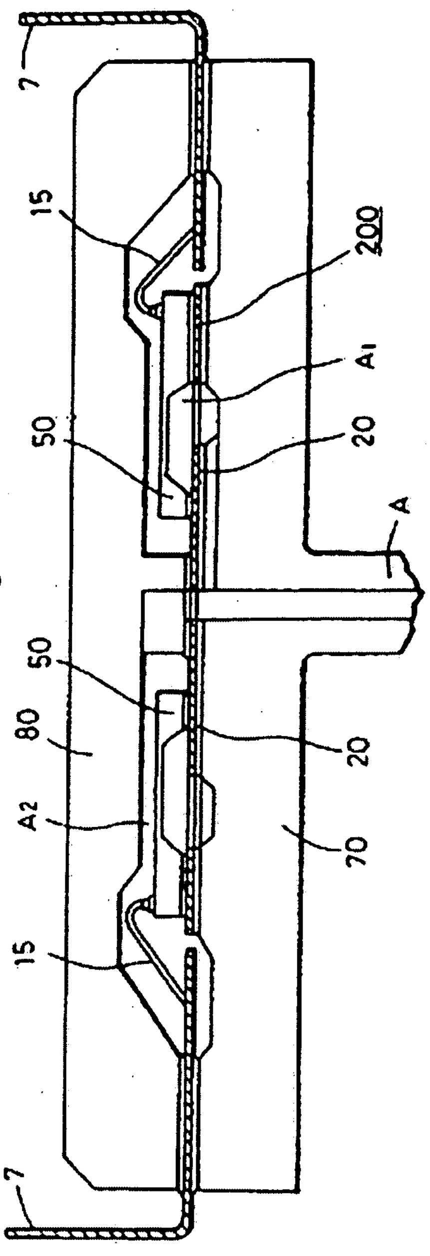


FIG. 21A

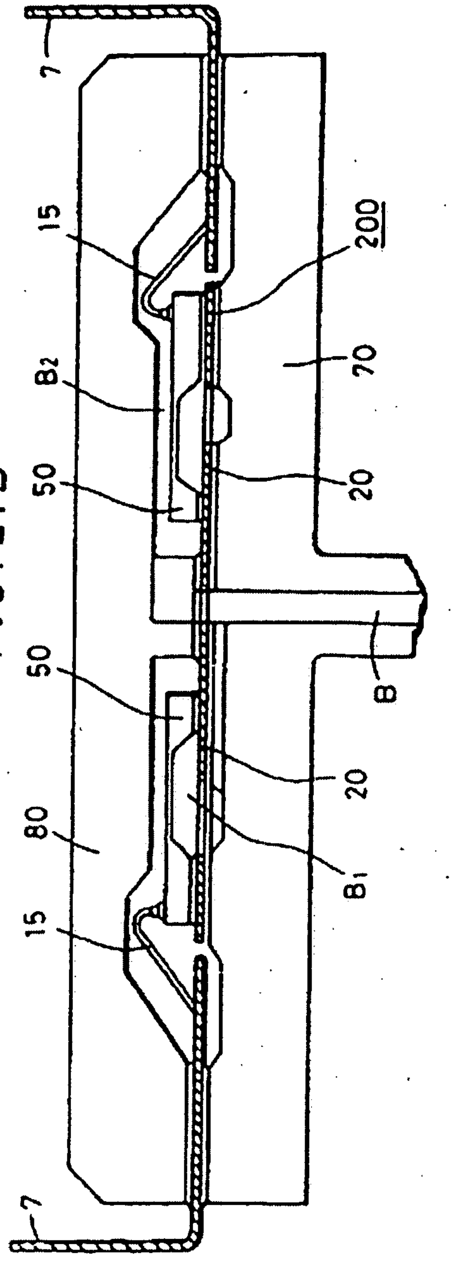


FIG. 21B

FIG. 21C